EXHIBIT D

Field Report
Marine Corps Systems Command Liaison Team
Central Iraq
20 April to 25 April 2003

Background ~ In support of Operation Iraqi Freedom, Marine Corps Systems Command (MCSC) fielded equipment in response to Urgent Universal Need Statements which provided additional capability to I MEF. At the request of the Combat Assessment Team, MCSC provided three officers to assess UNS / legacy system items. This was the second trip supported by MCSC personnel in theatre. The following locations were visited:

An Nasiriyah
Ad Diwaniyah

Observations ~ The following notes are based on discussions with Marines in the field. Accordingly, much of the information provided is subjective and opinion based. I would recommend appropriate and further review before taking action. Intent of this discussion is to highlight those areas where the Marine Corps, as an institution, should consider applying resources in order to improve the identified functional areas. This report is a result of the efforts of Capt Patricia Dienhart (PM, GTES), Capt Shannon Roos (PM, Tanks) and Capt Mike Howard (PM, IWS) who traveled current USMC battlespace to interview the Marines who are currently using the gear. Additionally, I conducted a number of camp interviews; those systems are included in this report:

Dust abatement – remains a high priority for the MEF and affects units throughout the battlespace. My personnel experience suggests that this type of materiel needs to come into theatre ASAP. Dust in certain areas is greater than 6" deep and very much like a fine talcum powder. Foot and vehicle traffic, along with ever-present winds, can reduce visibility to less than 50' feet in a matter of moments. Convoy operations become exceedingly difficult, air operations come to a halt and living conditions for Marines become intolerable. A bigger concern is that commanders in the field are faced with a Catch-22 situation of spraying oil on the ground (hazmat, environmental issues in a "win the hearts and minds environment") vs. functioning.

C4I Issues - Interoperability of various Communications equipment was an issue in all C3 vehicles and COCs (Tanks, LAR, AAVs). Marines were overwhelmed with the high number of varied communications equipment they were expected to use. Routinely, communicators, operations officers, and commanders found themselves in information overload as they received information over too many different networks (e.g. an LAV Marine was connected to the intercom via his CVC headset, receiving information on a personal intra squad radio (requiring him to remove his helmet to talk), while also (depending on the particular LAVs configuration) "working" 2-3 man portable radios to communicate with other units (PVC 5 for SEALs, PRC 148 for fellow Marines, etc) and "monitoring" two laptops). This situation was exacerbated in C3 vehicles where I personally saw that every "shelf" was taken up by a radio and seat spaces and floor spaces were taken up with open computers for communications devices such as Blue Force Tracker, MDACT, or Iridium phones. Marines recounted numerous instances where units would call via radio to verify that a message was received over MDACT, while the receiving unit had just put the MDACT aside to monitor BFT since a previous unit had called asking about the receipt of a digital photo over BFT. Consolidation of communications assets / capabilities is an issue that requires review at the institutional level. Commanders want one box that provides multiple capabilities and that is simple and easy to use.

Overwhelmingly, units were in agreement that communications architecture required an overhaul. There were too many different devices that provided redundant capabilities. Additionally, units never seemed to receive enough of ONE communications asset, forcing them to rely on a "hodge-podge" of assets that were not consistent throughout the force. (e.g. some units had only MDACT for digital communication while another unit had only Blue Force Tracker. These units could not talk to each other unless they went through a third party or used a courier system). A specific case occurred between LAR S-2 and the Div G-2, while attempting to send pictures from the Dragon Eye to Division HQ G-2. The S-2 had BFT readily available while the G-2 did not. The G-2 needed to "borrow" the commander's BFT to receive these messages or simply wait for a courier with a MEMOREX disk to arrive with the pictures. Time lost often rendered the pictures irrelevant in this fast paced fight. As the Operations Officer from 1st LAR stated, "the communications architecture is broken and the interoperability of various communications assets is virtually non-existent."

Satellite Communications - The only consistently reliable means of communication was "SATCOM." In this fast paced war, if a communications system was not functioning quickly, alternative methods were employed. This was a specific problem of the EPLRS radio (which relies on Line of Site (LOS)). With units constantly moving, over various terrain, LOS was not possible. Accordingly, any system connected to the EPLRS radio proved unreliable (e.g. MDACT, AFATDS, etc). The only systems consistently praised by the Marines were the Blue Force Tracker (SATCOM- though

unsecure) and Iridium Phones (SATCOM). These systems provided reliable communications at all times. In many instances these systems were the sole means of communication.

Many Marines noted MDACT, which has a larger bandwidth and greater capability for sending electronic information was marginalized by its dependence on the EPLRS (LOS) radio. As one commander stated, "Satellite Communications is simply the way of the future and the Marine Corps needs to start focusing on that." Rumor suggested the Army "gave" the Marine Corps satellite time *(note: I believe the USMC contracted bandwidth prior to crossing the LD)* in order to use the BFT; had this not been the case, the Marine Corps would have found itself fighting, in several instances, without tactical communication.

There were numerous comments regarding the fielding (plans) of gear. Consistently units felt "forgotten" in the fielding plans of various pieces of equipment. For example, Combat Engineer Battalion was not included in the original SAPI plate distribution; ultimately, they received inadequate numbers of SAPI plates the day prior to crossing the LD. CEB leadership was faced with hard questions from their Marines (e.g. literally, questions such as, "Why is {his} life more important than mine?"). EOD and LAR units consistently felt "left out" of the distribution of the latest combat gear *(note: these fielding issues should be reviewed by the appropriate Advocate and Requirements reps).* Additionally, if LAR was included in a fielding plan, they were treated similarly to "leg" infantry units; though structured differently (LAR battalions have four companies vice the traditional three of an infantry unit). This caused problems when items were fielded as "one per company" as invariably in a 4-company base one company would go without the newly fielded equipment. This problem became acute when one company was forced to use secondary communications, burdening the COC with monitoring two different radios for all their companies.

Logistics Trains - CSSG resupply trains were fired upon. However, their technology and armor was inferior to that of the divisions'. Marines without SAPI plates in soft skinned vehicles were the norm. "Rear area" units have elements that routinely operate on the "front lines". Though CSSGs did not face the same intensity and threats of Division units, they received fire and worked in a very hostile environment. As the tempo of the modern fight will cause differences between the front lines and rear areas to blur, Advocate level consideration needs to be given to more equitable fieldings of equipment. FSSG units need to be outfitted with more Blue Force Trackers, more high tech radios, and better-armored protection (SAPI plates, armored HMMWVs, etc).

Preliminary UNS Review ~ The following is a list of UNS / legacy items for which was gathered from the Marines that used them:

Fuel hoses and reels – One of success stories of the conflict and follow on HA mission. Approximately 70 miles of hoses and reel were laid that supported the MEF's movement without flaw. Despite supporting what were, arguably, the longest LOC's in recent USMC history, fuel was never a potential limiting feature of the war. The hose reel system outpaced the Army's installation of IPDS system. However, within the bulk fuel community, there is a concern that the wrong lessons will be learned. The fuel effort required the dedicated use of a bulk fuel company for the duration of the war. Once the lines were laid, they required high maintenance and the constant supervision / over watch of the skill sets resident in the dedicated engineer unit which supported the fuel lines.

TCDL suites - Systems were sent out to various MSCs to include the 1st UK Div and provided real time surveillance of the battlespace. The systems easy to use and proved to be reliable under a very harsh environment. The units requested additional systems as a result of this new capability that it gave the units. However, the limited availability of spares and FSR support for these systems were a concern.

Black Cell Suites – This equipment transmitted UAV video down to the Bn level increasing visibility of the battlespace. The systems were easy to use and set-up. However, the limited availability of spares was a concern. Additionally, due to limited availability, there were not enough Black Cell suites to support every unit that requested one.

Low Cost Receiver – This system proved very easy to use, was lightweight and "Marine Proof". The system never failed to work and was used to push information around the battlefield and every unit wanted one of these systems.

IOS Suites - Units want a small system during the next upgrade. Additionally, the units request a Windows platform, if available.

RTC – The system was never delivered to I MEF, but should have been procured earlier in the conflict. Could have been used by the Intel Fusion Cell. *(note: originally requested but ultimately dropped from the UNS process due to time. This was a recurrent theme. Many never had visibility on the MROC process and did not understand the*

resultant 60 – 75 day delay that was apparently evident to even the lower levels of the organizational structure. After explanation, many understood, but felt the process could have been expedited. Many could not get past the idea that 60 days was the difference between every UNS fielded vs. most UNS fielded.).

AFATDS – The following insights were drawn from MGySgt Albrecht, an artilleryman with 28 of experience. Until all parties return from the battlespace, I have only one view. Accordingly, issues below should be validated before any action is taken. His thoughts below:

- AFATDS works best when turned on and left on
- As a whole the system was not used as intended (with the exception of the firing batteries)
- 22 systems down before crossing the LD. Apparently the maintenance concept was in place, but force protection issues (2 car, 4 Marine rule coupled with requirement to have an 06 signed letter to get on / off base (Doha) complicated this maintenance cycle
- Dust caused the keyboards to go "down"
- Infantry units did use a fire support control tool.
- Arty units were able to process and clear missions in 45 seconds; Infy units took 25 minutes.
- Infy units cleared all missions by voice (hence the time disparity noted above)
- AFATDS with EPLRS worked perfectly; digital was always "up"
- SINCGARS trouble shooting with AFATDS is timely (15 seconds) and easy
- One comment from 2nd Tanks was that they had problems getting the system to function properly, especially on the move. Once the tank started vibrating the system would stop working; not sure if it was the vibration or loss of Line of Site.

MGySgt Albrecht's formal after action will be routed via his chain of command at MCSC.

MTVR – apparently there will be a large order of windshields for these assets as they were unable to withstand the overpressure of the Artillery's higher charges (Charge 8 Super). Comments regarding bed height, as noted in my last report, were the same; bed is too high. Also, a concern was raised that, in the future, as the trucks become older, maintenance will become a critical issue since Marines are not trained to fix the highly sophisticated computerized system. *CLS was not seen as a reliable solution. Marines, throughout the battlefield, of all ranks, were not in favor of contracted civilian support.*

Heavy Machine Gun (HMG) Mount ~ Both the AVS and MSG brands of HMG mounts worked well. Most reports were favorable. One operator indicated a flaw of the system was the tightness of the pintle. Sand often got in this area, which then locked the machine gun in one position. Operators alleviated the problem with routine PMs, suggesting the issue is likely to be due to the extreme sand problems of this environment.

Forward Air Controller (FAC) Suite/GLTD II ~ Operators who used the designator found that it performed acceptably. Operators in vehicle platforms (to include AAVs and tanks) would like to have a stabilized vehicle mounted variant.

The GLTD II system (non US version) was issued in a configuration that included components necessary for designating targets (a tripod, and a tracking head). The tracking head provided a means to attach the designator to the issued tripod (can't be done directly) and stabilize the designator for laser safety issues. The tracking head is a bulky, heavy apparatus that functions as the "trigger" for the rest of the system. The desire of the operators is to leave all unnecessary gear behind due to size and weight considerations. Most operators learned that by using the remote trigger cable, they wouldn't need the tracking head. Many left the tracking head and tripod behind. Many chose to use the tripod from the Viper (could be connected directly to designator) if tripod use was desired.

The FAC suites were not issued as requested in the UNS. The fielding team only issued the GLTD II laser designator suite. The PEQ-4 laser illuminators/markers and AN/PRC-7C night vision goggles went directly to Division and were distributed before the fielding team arrived in country. *(note: as the crossing of the LD became imminent, it was decided to field components as they came in, IOT some capability vice no capability. The GLTD II literally "just made it" and was the last item fielded before the LD was crossed).* Units already have assets to communicate with the aircraft (PRC-113), night vision devices (AN/PVS-7s, AN/PVS-14s) to spot the laser illumination, and AN/PVS-17C to give the GLTD II a "night sight capability". The AN/PVS-17C has a maximum effective range of 500m at a point target in ideal/perfect conditions. This distance is within the "danger close" area, and therefore doesn't give the system a night capability. Units didn't reallocate the AN/PVS-17's for the designators as the capability gained is far less than what is lost by taking them off they intended weapon platforms. Operators would like to be able to see the laser "splash" on the target from a piece of gear mounted to the
designator. They were unable to do this with the gear available. They also requested having a thermal site attached or mounted.

Operators were very impressed with the AN/PEQ-4 Laser Illuminator; which was used extensively. It was the primary tool used by the FAC's, especially when working with Cobras. They illuminated the target and once the pilot spotted it, he was able to control the mission. Many would like these issued beyond the FAC's. Often, smaller units (platoons, squads, teams) don't have a school trained FAC with them but need the capability. Users would prefer ISLD 1000 vice AN/PEQ-4 for increased capability; however, the PEQ-4 "answers the mail."

AN/PVS- 14 Night Vision Equipment ~ "Great piece of gear, need more." Some infantry units have one per man, (combined AN/PVS-14 and AN/PVS-7 assets), others, one per squad. Operators are asking to have one set of Night Vision Goggles (NVG's) per fire team; one per man is preferred. Units who received the M16A4 with ACOG scope/site would like to mount the NVG in front of the ACOG to give them a night shooting capability. For those who did this, they found the capability worked well. Some units couldn't mount the AN/PVS-14 on the 1913 RAIL (unknown if they had a different model, were missing parts, or lacked training). They taped the NVG on and had limited success. Actual mounting would be better.

Long Range Thermal Imager (SOPHIE) ~ Operators were amazed by the capability. They would like more of the capability but would like to see it in a smaller and lighter package that is vehicle mountable and stabilized. Operators needed more extensive training. They didn't really know what they were seeing.

AN-PAS 13 Thermal Weapon Site ~ "Amazing, need more." Many operators were able to see clearly to "10+ kilometers" under good conditions. In mild dust, they were also impressed since they could see "almost as far, 8+." Most reports were that they worked very well in all but the most extreme dust storms. Highlighted the need for thermal AFVID USMC wide! If PAS-13 gets wide distribution, infantry units will need rigorous AFVID ***THERMAL*** training. Currently, Tanks, LAV, Tow, and Air train to such standards. The proliferation of numerous hand held thermal devices without proper training could prove problematic. In addition, infrared can be viewed. Passing lanes proved problematic for some LAR vehicles that relied on thermals. Passives had to be used to spot IR chem.-lights. Thermal chem.-lights or beacons can prove costly.

AN/PVS 17 B and C ~ "Great gear, need more" across the board. Operators impressed with clarity and ability to ID targets. Operators particularly liked red dot reticule for point and shoot capability.

M16A4 with associated combat optic (ACOG 4x), the West Coast's SAM Rifle ~ All interviewed were extremely pleased with the performance and felt it "answered the mail" for the role of the Squad Advanced Marksman (SAM). All said the fixed 4-power ACOG sight that was included was the perfect solution. It gave them the ability to identify targets at distance, under poor conditions, and maintained ability to quickly acquire the target in the close in (MOUT/room clearing) environment. As above, many "stacked" it with the AN/PVS-14 to get a true night capability. No Marines present in interviews knew of any situation where the shooter could shoot the gun to its full capability or outshoot it. Interviewees included STA platoon leadership and members who are school trained MOS 8541 Snipers. They saw no need for the accuracy and expense involved in the version being built for the "East Coast" SAM Rifle by Precision Weapons Section (PWS), WTBN, Quantico. The standard M16A4 with issued optic more than satisfied their requirements.

Distribution among battalions varied. One battalion received (6), one went to each of the three line companies and three to STA Platoon for the spotters. Other battalions received one per rifle squad.

Regular M16A4's, no optic, were sent over to theatre to replace M16A2's. However, they arrived too late to be distributed and BZO'd prior to start of the war. These weapons remained in storage in Kuwait.

M4 Carbine ~ Many Marines commented on desire for the shorter weapon vice the longer M16's. They say that it would have definitely been better in the urban environment because of the confined spaces. Since most of the operators were operating from a vehicle platform, the smaller weapon would have helped tremendously for mounting and dismounting.

There were numerous comments that the M16 is too long and cumbersome in the urban fight. Several Marines even opted to use the AK-47s that had been captured from Iraqi weapons caches. Others were trading the rifle for pistols to go into buildings to allow mobility in confined spaces.

There has been a push to get M-4's to crewmen of the mechanized vehicles, LAR in particular. The distribution needs to include LAR, AAV's, Tanks, Motor Transportation, and any other units that may have a requirement. IWS has fielded some assets to LAR, but not all others. LAR still has mostly M16's. The M-16's are too cumbersome/long for crewmen to employ (get out of the cupola or out of a door/window) in a timely manner while under stress such as when receiving fire.

M249 Squad Automatic Weapon (SAW) ~ The SAW's are worn out and apparently beyond repair. They have far exceeded their service life. Many Marines are duct taping and zip tying the weapons together. Reconnaissance units were requesting parasaw, infantry units requesting collapsible buttstock.

5.56mm vs. 7.62 Lethality ~ 5.56mm "definitely answered the mail" and "as long as the shots were in the head or chest they went down" were typical quotes from several Marines; many who were previously very skeptical of 5.56mm ammunition. Most of the interviewed Marines who reported targets not going down and/or could still fight were referencing non-lethal shots to the extremities. There were reports of targets receiving shots in the vitals and not going down. These stories need not be described, but are of the rare superhuman occurrences that defy logic and caliber of round. Some Marines did ask about getting the heaver-grained 5.56mm rounds, up to 77 grain if possible.

M9 Pistol Magazines ~ The magazines are not working properly. The springs are extremely weak and the follower does not move forward when rounds are removed. If the magazine is in the weapon, malfunctions result. If out of the weapon, remaining rounds fall out of the magazine. Dirt and sand does cause some of the problem with follower movement, but multiple cleanings of the magazine each day does not alleviate the problem. The main problem is the weak/worn springs. *(note: I personally encountered this problem as well. Say what you will, but I had to break down all magazines daily to clean them. Despite this effort, rounds routinely "fell" out of the magazine. Forces in contact did not have the time or the luxury to break down each 9mm magazine daily. M16 magazines worked well. Like many officers, I also traded up to a rifle).*

Weapon Backup ~ Many infantrymen are requesting that all operators have an issued backup weapon, (i.e. M9 pistol) to augment their T/O weapon. If they can't get pistols for secondary weapon purposes, they need more pistols available for MOUT operations to operate in very confined spaces, stairwells, etc. They request at least one per squad; minimum, one per fire team; better.

Rifle Propelled Grenade ~ Many Marines are requesting Rifle Propelled grenades to augment or replace the M203. The M203 doesn't have an adequate range capability. *(note: this desire stems from the fact that the most effective weapon employed against coalition forces was the RPG).*

M240G Medium Machine Gun ~ Marines who did not really know what to expect were extremely impressed with effects on target.

M203 Load Bearing ~ Grenade bearing vests don't hold enough ammunition. Rounds don't fit into many of the pockets, so grenadiers aren't able to carry as many rounds as the vest is designed to carry. They aren't able to fit rounds into all of the pouches. Grenadiers are coming up with several different "band-aid" solutions to carry enough ammunition, most of which are not working. The Marines interviewed would like a vest that will hold at least 20 HE rounds plus 4 illumination rounds; 24 total rounds.

Grenade Pouches ~ Marines (at least infantry) need more than the two that are on the load bearing vest and/or issued with MOLLE. The MOLLE pouches aren't holding the grenades properly, "pins are falling out".

Viper ~ Operators saying "great gear, need more". Operators are getting good azimuth and distance to target. However, they are unable to get the target grid location as advertised. "Zero maintenance Problems." Used with Fire Support Teams. None came in for optics maintenance complaint. Desire for system to be linked to Thermal Imaging System (TIS) Designators. FACs for 2D Tank Battalion highlighted the need for a laser designator specific for moving vehicles with extended range compatible with FEP. GLTD II was useful but not on the move. MULE is obsolete and not practically mountable on tanks without loss of loader's M240 machine at that station.

TOW 2 ~ Operators are extremely happy with the performance. Several operators reported tank (T-72) catastrophic (K) kills. TOW 2B caused some concern when shooting over any metal (such as around the oil fields) and around "friendlies" because of the one sensor. The operators already knew these factors. The TOW 2A had no such concerns. The one downside comment (a constant theme by all interviewed), had to do with training. For gunners trained on the newer sight, they are great. For the untrained on the new system, gunners are unable to identify and range targets, etc. Many operators are also having a tendency to follow the rocket with the sight when the rocket rises above the gun-target line, instead of leaving the site on target. This causes the rocket to go higher and higher as the operator follows the rocket. Sometimes they recover and hit the target, most of the time they don't.

Additionally, the TOW sites are being successfully used for surveillance purposes. Operators are impressed with the capabilities the site offers in this area.

PRC-148 and Inter Squad Radios (IRR) ~ "Great gear, need more for everyone". One problem is that the power switch is prone to breaking off. Great to have capability to talk UHF (line of sight) for inter/intra team communications and to talk to aircraft for FAC/CAS purposes. Users also like VHF capability, especially in environment/terrain that does not allow line of site communications (i.e. urban areas). The ISR radio, operators say it is adequate in the open terrain as long as distance between radios is close enough. The radio is not good in urban environment due to operators' inability to communicate around corners, between floors or rooms, nor is the range adequate. Marines want VHF capability to talk in urban and other environments. Users would rather have the 148's across the board. One issue with the PRC 148 radios is the requirement for AC power to recharge. Vehicles use DC power; therefore invertors are needed.

M1014 Joint Service Shotgun / Breaching Kit ~ Units lack a means to mechanically breach in the MOUT environment. Some units bought kits from various vendors with their own funds. Satisfaction with various kits was determined by success of breaching, which is the result of what they were breaching and whether the kit had the right gear for the given situation (usually
dependent on what the unit spent on the kit). Many operators pointed out that battering rams proved ineffective against most doors encountered. A majority of the doors (both interior and exterior) were heavy steel and often reinforced with cross bars. Most agreed that, at a minimum, small units need to have a shotgun to breach the doors. For units both with and without the kits, the shotguns would have made them more successful. Only six (6) M1014 shotguns were issued to each infantry battalion. This quantity is not enough. Operators are asking for at least one per squad at a minimum. The round/ammunition that was needed in this environment was the slug. Units tried using 00 Buck, which did not work well. CEB expressed a desire to have more urban breaching tools (they were always short), more route reconnaissance kits, and more tactical bolt cutters (short version).

SMAW Thermobaric (New) Round ~ Only received reports of two shots. One unit disintegrated a large one-story masonry type building with one round from 100 meters. They were extremely impressed. However, another unit tried to breach a wall of a similar masonry building after being unsuccessful at trying to mechanically breach a door. "The round just bounced off the wall." They were not so impressed.

Weapon Take-Down Pins ~ Many weapons, M16 and M249 in particular, were having problems with takedown pins breaking and/or falling completely out of the weapons. Marines held weapons together with duct tape and/or zip ties. The problem seems to be that sand would get into the spaces around the pins, grinding down the metal.

Enemy Engagements ~ Almost all interviewed stated all firefight engagements conducted with small arms (5.56mm guns) occurred in the twenty to thirty (20-30) meter range. Shots over 100m were rare. The maximum range was less than 300m. Of those interviewed, most sniper shots were taken at distances well under 300m, only one greater than 300m (608m during the day). After talking to the leadership from various sniper platoons and individuals, there was not enough confidence in the optical gear (Simrad or AN/PVS-10) to take a night shot under the given conditions at ranges over 300m. Most Marines agreed they would "push" a max range of 200m only.

Line Haul ~ Interviews with 15th MEU(SOC) preferred the British "container" method of transport. US Marines (MSSG S-3, S-3A, and MEU S-3) stated that a similar system would be very useful to the USMC. A request for purchases of many more iso-containers and Mk 48-18s was vocalized. Vice using the current system of hauling and offloading gear with 5-tons, LVSs and MHE; the USMC should consider using more MK 48-18 trailers with containers. The idea is to drive loaded containers to their designated site, offload them w/ the crane on the Mk 48-18, and return the trailer to the supply point in order to pick-up the next load. If the using unit had emptied containers these empty containers would be returned to the supply source for reloading. This is the method used by the British, which, according to members of 15th MEU, was at least 3 times as efficient as our current system. There is virtually no reliance on heavy equipment at the offload site and units are immediately provided with a secure storage container. However, this methodology would require an increase in containers and Mk 48-18s throughout the USMC. *(note: Line haul was a problem for the USMC given the amount of materiel and increased distances log support had to travel. The MEF G4 was very successful at resolving this issue through careful coordination with all forces in the battlespace. A bigger problem, which remains unsolved, is distribution. There is no control of materiel once a convoy reaches its first destination. The USMC needs to revisit the role TMO Marines can play, as well as improving tools that can effectively track gear from one point to another.)*

Field Report
Marine Corps Systems Command Liaison Team
Central Iraq
20 April to 25 April 2003

ROWPUs ~ Reverse Osmosis Water Purification Units received nothing but praise from various members of the 15th MEU(SOC). The only concern raised was that the units were getting old, would run rough at times, and were performing past their life expectancy. There was concern with how much longer they would operate. Accordingly, there were recommendations for fielding the next generation of ROWPUs.

Power Converters ~ A question arose with respect to the purchase of power converters from 220v to 110v and vice versa. This could become a part of the electrician's T/E. There were numerous instances where local gear could have been used (generators, pumps, etc) however, the lack of power converters prevented use of the gear.

NBC/ Gas Mask Voice Amplifiers ~ This gear received positive feedback. Marines requested that one voice amplifier be issued with each gas mask.

SABRES ~ The current Sabres tend to lose their crypto fill while changing batteries. Marines of 15th MEU stated that the Sabres seem to be "getting old" and should be replaced with a lighter, smaller, more reliable system.

BA5590s ~ With the obvious shortage of BA5590s the Marines were asking for more alternative sources of power. Rechargeable batteries were requested. There was also discussion of a "radio bank" where 6-7 radios could be run off of one "bank" that received its power directly from a generator source. Also, many of the radios were semi-permanent fixtures to COCs. These radios, had been "jerry-rigged" by the Marines with a device allowing them to receive their power directly from the generator vice a battery. A commercial system with similar capability was requested. *(note: SysCom's international efforts added two DOS to the fight, at a time where it was not clear if we would run out of batteries before we ran out of war. This battery problem affects DoD).*

Drop Holsters and "phone dummy chords" ~ Many Marines purchased these items from their own personal funds. Drop holsters (such as the kind purchased through the company, "Special Operations Equipment") cost approximately $65. Marines would like to see these holsters issued with their pistols. Also, Marines fashioned pistol lanyards from phone chords. These lanyards retract and thus are much less cumbersome or likely to get caught than the current lanyard. Marines would like to see this type of lanyard fielded.

Three-Point Slings ~ Marine unit funds and individual funds were used to purchase three-point slings for M16A2 service rifles. These were used or "fabricated" by numerous Marines and received much praise. Marines requested that each of these be issued with each M16A2. An example of one such sling is the "Giles Tactical Carbine Sling" made by "The Wilderness Tactical Products" (www.thewilderness.com).

Goggles ~ The current goggles used by Marines received very poor feedback. They were too large, did not seal properly, and the lenses often popped out of the frame. Numerous Marines purchased goggles that were smaller and better contoured to the face. One such version is the "Panoptx" brand; Marines were enthusiastic about these goggles and asked for the USMC to field a similar version.

Ruggedized Computers ~ These worked well and received positive feedback. One drawback was that they tended to run very hot; users could not even touch the front area of the keyboard.

Generators ~ Marines from numerous units were requesting more generators and power distribution assets. Units noted that systems (especially Communications systems) were fielded that required much more power than current systems, yet there was no accompanying generator or power distribution gear to supplement the newly fielded system. LAR raised a request for a small generator that could be attached to the side of their C3 LAV.

LMT (Lightweight Mobile Tactical) Water Purification System ~ There were several complaints about the "flimsy" construction of the LMT. Most components were made of easily breakable plastic. Also, the purification of the LMT was not enough to purify the fresh water from the Euphrates River; its' effectiveness and usefulness was questioned. A small system was a "good concept" however, the purification capability needed to be greater.

3000 gallon Water Bladders ~ Marines in the Utilities field admired the 3000 gallon water bladders used by the Seabees. These bladders were very effective as a sealed water storage capability. The current 3000-gallon "onion skins" were good for raw water storage, but not purified water. Also, the 500-gallon pods were not a large enough storage capability for purified water.

Water Pumps ~ The 165gpm pump was very effective in pulling water from its sources. The 125gpm pump, though intended for this purpose, was ineffective. It lacked the power to draw water from any source that was not completely flat. More 165gpm pumps were requested as a replacement for the ineffective 125gpm pump.

MEP TQ Generators ~ Sand caused many problems with the functioning of the generators. One recommendation by the electricians was to better seal the control panel/cubicle to keep out the sand. The master-switch often broke due to sand getting into the crevices. Also, the air filter system seemed to be ineffective. The electrician stated he would clean the air filter every day and literally shook out handfuls of sand each time. He stated that a more effective system that did not get clogged so quickly should be researched.

MEPDIS (Mobile Electric Power Distribution System) Gear ~ The mix of cables in the MEPDIS gear is not ideal. Electricians were asking for at least double the amount of 25ft extensions that came with the MEPDIS gear. Also, the 30kw power distribution panels need more 20-amp breakers.

SAPI (Small Arms Protective Insert) ~ To no surprise this item was worth its weight in gold. SAPI plates saved lives. In five separate incidents at 2D Tank Battalion the SAPI prevented death or serious injury. In the words of Capt. David Bardorf, 2D Tank Bn., "SAPI is God's gift to the Marine Corps."

Marines were hoping that the future could bring a lighter version that was slightly wider in the front, but these requests for modification were minimal and insignificant compared to the positive feedback and effectiveness of the plates.

.50 Caliber Machine Gun ~ Great piece of gear; but would like to see a rail mount on the .50-cal. This is to include the versions outside of M2 for infantry. Tankers and others would like the capability on their guns.

MOLLE Gear ~ Marines uniformly and strongly DISLIKED this item. The pack was considered too loose from the frame allowing it to move too much while the Marines were hiking. Marines asked for a tighter pack similar to the ALICE pack. The plastic frame was labeled "cheap" and broke on numerous occasions. This was especially the case when Marines tied these packs to the outsides of vehicles (LAVs, Tanks, HMMWVs, etc) for transport resulting in broken plastic frames.

Sleeping Bag ~ Several taller Marines complained of the length, stating they could never get fully inside the bag. They requested at least one foot of additional length.

LAVs ~ The LAV community had favorable comments about the LAV. However, the concern was raised that LAVs are getting old, requiring increased maintenance. A replacement was desired for the near future.

Combat ID Panel ~ These were highly desired and utilized. However, they were obtained by borrowing panels from the Army as well as fabricating panels prior to crossing the LD. Several Marines emphasized that Combat ID panels are a necessity for war; the USMC needs to field these critical fratricide prevention devices.

OS-302 Antenna ~ This was labeled as "very effective and reliable but much too big." Marines pointed out that the CIA and SEALs had a small omni directional antenna that is approximately 1" in diameter and 6" tall that would be much less cumbersome and preferred.

Phrase-later ~ This was another small open purchase item that was purchased through unit funds. It consists of a small "palm pilot" size computer system that translates phrases into the desired language. This was used on numerous occasions to ask simple questions of locals and EPWs (with heavy usage at checkpoints). Recommend C4I or CESS look at providing to deploying units. The system is manufactured by Maine Acoustics.

Iridium Phones ~ There was a lot of positive feedback on the Iridium phone. Due to its ability to be used when not in Line of Site, these phones were often used for communication. It was a highly reliable means for the forces to continually be in contact with one another.

Comm Suite in AAV ~ Not highly received; comments were made that the Comm Suite needed an overhaul. One major downfall of the suite is its lack of capability of HF transmission when on the move.

AAV as Tank's C3 vehicle ~ A concern was raised with respect to the comparatively lightly armored AAV being the C3 vehicle and thus employed with the Tank battalion. Those in the AAV felt vulnerable to enemy fire when engaged in a battle with the Tank Battalion.

870 Trailers ~ These trailers (both the A1 and A2 version) were found to be too flimsy for hauling assets over long distances, especially when hauling over all-terrain. The tires and rims would routinely going flat and bend

D9 Dozer ~ These bulldozers received highly favorable reviews from all that benefited from their use. They were seen clearing a row of buildings effectively within an extremely short period of time. Also, they were used in quickly clearing a highway for use and constructing hasty combat roads. Marines stated that the D9 can do the equivalent of approximately (4) D7 dozers. They would like to see this Dozer employed in more operations in the future.

SEE Tractors ~ A trend in the SEE Tractor was its tendency to roll on embanked terrain. It was also noted that this particular piece of gear was getting old and a replacement was desired. A concern was raised with fielding a backhoe that would not be able to keep up with convoys. Marines relied heavily on gear that was self-moved, due to limited lift assets. A desire for a backhoe capable of maintaining convoy speed was expressed. A backhoe that would require lift was not a desired option.

ACE ~ Although an effective piece of equipment when employed in its role, the ACE was found to have problems keeping up with the Tank battalions. The hydraulics continued to burst, requiring it to be left behind due to maintenance concerns. Modifications conducted on the ACE just prior to deployment reportedly increased their effectiveness and ability to perform.

TRAMS ~ TRAMS continue to prove to be a reliable "workhorse." This MHE asset is used more than any other. Marines expressed their satisfaction and continued desire for "more TRAMS."

D7 TPK (Tractor Protection Kit) ~ Although the concept of the TPK was praised, its usefulness was questioned. The visibility of a TPK D7 Dozer was "horrible." It was noted that the "hole" for vision is ineffective and sight blocks are a "must have" for the TPK to be employed effectively.

Mine Detectors ~ These received poor reviews. They were labeled "flimsy" and "inaccurate." The Marines of the Combat Engineer Battalion recommended a review of the ANPSC-12 (in Albany). They desired to test these to see if they would be more effective.

Hoses for Heavy Equipment (hydraulic, etc) ~ A desire for screw on hoses was expressed vice the quick connect. These hoses can be quickly fabricated to replace broken hoses thereby immediately returning the equipment to an "up" status. Quick connect hoses are difficult to repair in the field environment.

Gas Mask Carrier ~ The gas mask carrier was not favorably received. When donning a gas mask, many Marines lose the extra injectors or medications they are required to carry. Also, there was not sufficient room for the extra filter. The carrier needs to have more compartments and also needs to be a bit larger in size in order to hold the extra gear that is issued (medications, injectors, TM, filters, etc.)

Maintenance Contact Truck ~ The pneumatic tools in the contact truck were not sufficient to break lug nuts off of vehicle tires. Maintenance Marines expressed a desire to have a larger, sturdier vehicle with heavier, more capable tools. With the amount of gear mechanics are required to fix and the criticality of performing their maintenance in a minimal amount of time heavier tools were a necessity.

Demolition Kits ~ The new electric firing system received "rave reviews." It was considered safer and more effective. However, the durability of the firing device was poor.

Carpenter's Tool Kit and Pioneer Tool Kit ~ Numerous comments were received on these kits. The kits need an "overhaul" and need to be "updated to the 21st century." Marines in the field left at least ½ of the tools behind. In particular the non-power hand cranked tools (e.g. drill) were left behind.

Minefield Marking Kit ~ The kit's hem spools did not get used. Also the poles did not penetrate the ground very well (they broke or were not in the ground deep enough to stay in place). The poles also took too long to place in the ground. CEB ended up using 100's of orange cones (such as seen at construction sites) to mark UXOs, vice utilizing the kits.

Anti-Personnel Obstacle Breaching System (APOBS) ~ Each compound is too heavy and the range is considered ineffective. The range of approximately 25 meters was questioned. As one Marine stated, "Why should I lug a 50lb piece of gear around that only clears 25 meters when I can just mark it for EOD and walk around the obstacle?" The bangalore torpedo was still a preferred breaching system for obstacles.

Tents and One-Bag Showers ~ The new tents (2 man) received many compliments. Also, some Marines had purchased one-bag showers prior to deploying. These received favorable reviews and it was suggested that the USMC field them to Marines.

Line Charge Trailers ~ This equipment is "flimsy" and "unreliable." On rough terrain the trailer can be towed barely over 5 mph before breaking.

DC inverters for HMMWV ~ Marines were very happy with the results of this item. They wanted more fielded (e.g. at least one per vehicle).

GPS ~ Battalions have purchased numerous GPS on the commercial market. The commercial market produced smaller, lighter, and more easily used GPS.

Memory Sticks ~ "Great information transmitting medium". Often images/intel was passed via courier vice over the net (the net was too slow and unreliable) from the front units to the HQ G-2.

VMU ~ Video feeds were great, however, they needed to have grid coordinates, date, and time on all video feeds or else they are completely useless.

Dragon Eye ~ Division HQ G-2's Dragon eye was used for a week, prior to crossing the LD. However, prior to crossing the LD the computer went down and there was no maintenance plan in place. *(note: there was a maintenance plan in place. It is not clear, however, how much of this plan the operators were aware of).* Thus, the HQ G-2 did not utilize the system. However, the week that the Dragon Eye was used it received favorable comments.

Extensive analysis and feedback was received from 1st LAR's S-2 section on the Dragon Eye. They used this system daily throughout the war. Overall the system was highly regarded and the S-2 section was extremely happy to have it as a tool for their intelligence gathering.

The system's outer shell was characterized as "flimsy" and not durable enough. The harsh sandy environment immediately caused excessive wear. The rubber bands used for launch of the system consistently broke. Users stated that at least 10-15 extra launching bands were needed to be fielded with the system. There was no maintenance plan in case of an item breaking. CLS was discussed and immediately disregarded. Contracted civilians were not desired in the battle-space. Training for the Dragon Eye was minimal and all Marines desired more detailed training. They hoped that this training would be incorporated at the schools and throughout the fleet.

Batteries were a critical vulnerability of the dragon eye. Not only did the battery run out, but finding a replacement battery in a timely manner was nearly impossible. The battery used was company specific. Marines desired a rechargeable battery or as a second choice a battery that was easily purchased on the open market.

Night use of the dragon eye was poor. An infrared camera would be a usable addition to the dragon eye. Also some kind of infrared strobe would be helpful, especially in locating the dragon eye upon landing. Marines had trouble finding the small "plane" when it returned from a mission, especially at night.

The range of the dragon eye was acceptable, but as always, more was desired. A desire for retrans was voiced in order to extend the range.

Overall, a recurring concern was communication from the ground with the system. The operators found that the signal received on the computer often "cut out" and no video feed was received. At times the operator desired to abort the mission however he could not "contact" the Dragon Eye. When the system was up and running the video resolution was very clear and easy to read/decipher. However, Marines found the 10km range somewhat insufficient; ideal would be a range of 20km. The current altitude of the system was also found to be insufficient. For clearer pictures and easier deciphering the Marines desired the system to be capable of being flown as low as 100ft. Flight duration (currently 1 hour) was also insufficient; ideal desired time would have been 2 hours.

Finally, the laptop had a few features that could have been a bit more "user friendly." The method of looking at numerous pictures at one time was very cumbersome and needs to become more "user friendly" (i.e. double click on one icon to open a picture vice filtering through various tool bars). Also, the laptop needs to be plugged in; a rechargeable battery option would be good for an infantry Marine in the field. On a "positive note" the size and weight of the Dragon Eye were considered ideal. If given the choice of keeping the current capability and thus maintaining size and weight or increasing the capability/technology with the result of a dramatically heavier and larger machine the Marines overwhelmingly would choose the former.

Imagery ~ Imagery from various systems did not make it to the HQ G-2 level on numerous occasions due to a lack of bandwidth and electronic imagery transferal means. BFT did not possess the bandwidth for larger files and MDACT was unreliable as a communications means due to its limitation on Line of Site communication with the EPLRS radio.

Ambulance ~ M997 received great reviews and was considered "very sturdy." A few modifications that were voiced include:

-Corpsmen and Doctors would like to have bullet proof glass in the Ambulance
-A very small refrigerator would be useful for the transport of "immunizations"
-The space inside the ambulance needs to be reworked for greater efficiency; more "shelving and containers for various medical tools and medications" was desired. Also, the racks for the cots were not used, considered too cumbersome.
-Much gear was strapped to the top of the ambulance and a rack system on the roof would be very useful.

Corpsmen's Medical MOLLE Bag ~ As with the Marines' MOLLE gear this bag did not receive favorable reviews. Several alternative options were voiced:

-Corpsmen want to see something similar to the old "Unit 1" bag
-Corpsmen would like to see something similar to an LBV with numerous pockets for medications, bandages, etc.
-Corpsmen spoke favorably of something similar to the blackhawk version bag that the Army Medics carry.

Stretchers ~ The NBC stretchers were used often and proved to be sturdy and effective. The older, fabric stretchers tore often and were thrown out.

AMALS ~ The contents of the AMALS was disproportionate to the use. The AMALS kit was designed for severe trauma. However, it was completely inadequate for routine sick-call. Corpsmen quickly ran out of items such as cough syrup, Sudafed, etc. An analysis of what is REALLY used was requested in order to properly outfit the AMALS in the future.

PRC 150 ~ Labeled an "outstanding radio." It was very effective for long haul digital communications. LAR units desire a vehicle mount and a tie-in with the LAV's intercom system. Frequency hopping was a very good feature. More of this radio was desired.

IOS/IOW ~ COP- when this gear functioned its features were "great." However, the EPLRS radio proved to be very sensitive and unreliable. LAR had four that went down prior to crossing the LD (while still in the LSA). The civilian contractors were available for troubleshooting, yet were still not able to get the system to function.

PSC 5D ~ LAR had a few of these radios and found them to be very effective. LAR worked often with the USN SEALs. The SEALs communicated mostly via PSC 5D; LAR was limited to communication with the SEALs due to limited SatCom / limited PSC 5Ds. They would like more of these radios.

Kevlar Helmets ~ Very positive feedback received. During urban fighting in Iraq, a Marine Corporal was struck in the front of his helmet by a 7.62 x 39mm round. The Kevlar PASGT helmet absorbed the impact of the round with no injury to the Marine.

Combat Vehicle Crewman (CVC) Helmets ~ Overall, vehicles crews had favorable response to the CVC helmets. A few keys observations were made, however. Marines pointed out the ***need for Night Vision Goggle mounts*** for CVC helmets, a common observation in both LAR and Tanks. CVC helmets were also suggested for Tank Scout Platoon and TOW Marines. The reason cited by First Lieutenant Zumo, Scout Platoon Commander, 2D Tank Battalion, was that noise at high rates of speed presented problems. Crewmen manning heavy weapons ring mount station on HMMWVs

had difficulty hearing other crewmen. Problems communicating on radios for the Plt Cmdr/ Plt Sergeant were also noted.

Combat Vehicle Crewman (CVC) "Nomex" Coveralls ~ Several Vehicle crewmen complained that Nomex Combat Vehicle Crewman coveralls need improving. Crews observed that coveralls and gloves easily tore. Replacement garments were in short supply. The requirement exists for a more durable and flame retardant garment for combat vehicle crews.

Flexcell Extended Range External Mount Fuel Bladders ("Flexcells") ~ "The system is good." Recommended a mounting system for LAV-25. System was used in the Log variant LAV (by being placed in rear) and in the beds of rolling stock. Provide additional "in stride" refueling capability that assisted in the long and rapid USMC advance into Iraq. The flexcell allowed 2D Battalion to conduct an in stride refueling of the battalion in less than 90 minutes, 80 kilometers inside Iraqi territory the first night of the ground war. One company reported having a single tank refueled and operational in under 3 minutes. The flexcells aided the battalion in its six hundred mile trek into Iraq. Increased weight of flexcells was a problem, however. The combined weight of the full flexcell bladders mounted to the M1A1 turret and bustle rack extension tended to burn up motor brakes on the tank turrets. One tank company commander said his Marines were going through three to four turret motor brakes per vehicle per week. Also two tanks were lost as result of damage to flexcells. One tank hit a tree causing a flexcell pod to rupture. Fuel leaked into the engine compartment causing the engine to FOD out and the turbine to burn up. The tank had to be evacuated. There were no casualties. Second instance, an M1A1 received small arms fire. Again, fuel leaked into the engine compartment with same result. The tank caught fire and had to be abandoned during combat. The stationary tank remained under small arms and repeated RPG fire at close range. Under cover of darkness, an Iraqi irregular tossed a Molotov cocktail into the empty tank. This coupled with the burning engine and the multiple RPG hits resulted in a total loss of the tank. It is recommended that the bladders be configured for hull mounting along the skirts. However, this configuration could cause track maintenance problems since access would be impeded. Another criticism was the quick release straps. Flexcells were not quick release capable according to Marines.

Full Width Mine Plows (FWMP) "The Pearson Plow" – in my earlier report I wrote, "*of the 20 plows procured, only 11 went forward. Of this 11, I saw 3 on the highways of Iraq. Presumably cut lose as units went forward, it appears the plows are now combat losses. The 3 I saw were laying in the highway; burned out.*" Apparently, the weld mounts on the plows did not hold and broke from the body of the tank. This may account for the 3 I saw on the highway. The fielding team observed an incidence of this during the application of the hardware and repaired. The 5-ton trucks used to transport the FWMPs broke down. At no time did 2D Tank Battalion employ its FWMP or Track Width Mine Plows.

Even though 2D Tanks did not use the FWMPs, LtCol Oehl, the battalion commander, stated the item had its merits. It "did not drastically reduce the effectiveness of the tank" as implied by junior Marines in 2D Tank Bn. He noted it would have been a valuable asset had the mission called for breaching a minefield. LtCol Oehl also supported the FWMP for use on the Armored Breacher Vehicle (ABV).

Blue Force Tracker (BFT) ~ The Blue Force Tracker proved very popular with Marines from both LAR and 2D Tank Battalion. The 5.1 MB download capability proved to be very useful. Real-time information transfer and satellite imagery was mission critical on several occasions. BFT was considered "very responsive" due to instant messaging capability. Most of the commanders agreed that the pace of the battle required a device similar to Blue Force Tracker. Units were, at times, unable to maintain VHF over distance due to the inability to establish retransmission sites. Potential retrans sites would be forecasted to be located in unsecure areas. In the absence of communications, BFT provided units with responsive message traffic. Tanks and LAR used it in the absence of radios. It was, at times, the only means of communication for dispersed units. BFT was considered very reliable for providing friendly situation reports. Many officers and senior enlisted felt that the Scout Platoon and Alpha and Bravo commands needed this capability. It was recommend that at least 24 systems should be fielded per battalion, two tanks at the platoon level.

(An interesting suggestion made by Capt. Martinez, 2D Tank Battalion supply officer was that some logistics request system utilizing satellite uplink is preferred to line of sight communication system).

Capt. Garcia, CO of Company B, 2D Tank Battalion, voiced one criticism. He stated the method of mounting needs to be revisited. The mount for the M1A1 MBT stands out since it is placed on the rear of the bustle rack extension. One BFT on a Company B tank was lost when an armored ambulance clipped a tank when its turret was over the side. The BFT itself was rugged and survived but the mount was crushed. Capt. Garcia recommend the mounting system used on the M1A1 Delta variant be considered for USMC tanks.

M-DACT ~ Comments suggest that it was a highly unreliable due to the system's reliance on having the server up constantly. The system was marginalized when an active server hub went down. There were reported instances of units showing up in the "wrong" country. Some units appeared miles away from their known locations. This effected confidence in the system. Some Marines claimed it was too complicated to use. Windows pull down menus on a small screen made accessing information time consuming and difficult under combat conditions. This feature was also cumbersome while traveling at high rates of speed over difficult terrain. Transmission with the 56K modem took four to five minutes to send out a message. Other concerns included the screen being too small and not being user friendly. The MDACT system was noted to have great capabilities and was considered a "good concept" however, on the user level it was not employed due to its unreliability. BFT was preferred and MDACT was ignored.

Firepower Enhancement Program (FEP) Raytheon/ DRS ~ Comments on the FEP include the following: Position location capability and the ability to range a target and get a ten-digit grid were considered very useful. It proved valuable in fire missions and situation awareness. The fifty-magnification sight needs better resolution but proved useful. Thermal Bloom (washout in the TIS sites from fire trenches and burning vehicles) took one to three minutes of recover. Raytheon FEP site engaged vehicles in excess of 2300m. Was used by Bravo Company to Identify Snipers in buildings. Used as land navigation tool during road marches. Worked well in open terrain and built-up areas. One criticism of the Raytheon FEP was that it took four minutes for the Far Target Locator to align. It was the opinion of the experienced crews that it was impractical to sit idle for that period of time in the combat environment. On several occasions, the crew rolled without FTL alignment due to time constraints. The crew then had no option but to fight the tank in degraded mode. They recommend a 30 second alignment process. In static positions the FEP site was used to provide over watch for the tank company and to friendly infantry patrolling forward of lines. Crews recommended retaining the binocular site at the gunner's station. The ability to see in both day and night with the GPS and binocular site was very popular and useful to tank gunners.

M88A2 Hercules Tracked Recovery Vehicle ~ The M88A2 was rated as an excellent recovery asset. However, the general comment was that there were not enough of them. The original quantity of two M88A1 was reduced to one M88A2 for each tank company on the T/O. The long trek into Iraq resulted in many self-recovery operations (tank towing tank) due to the lack of recovery assets. This tied up needed combat power. Recommend USMC revisit the T/O of tank battalions to add at least two additional M88A2s per battalion on MPF. Some units used M88A2 as an armored ambulance. Cpl. Myhre, Company A. 2D Tank Bn modified one M88A2 with a loaders M240 7.62mm machine mount from an M1A1 tank. This modification gave the M88A2 another weapons station in addition to its .50 M2 Machine gun. Recommend more tow bars for tank units (*note: there are not of enough tow bars of all types to support all equipment in the operating forces. The USMC needs to revisit this issue and invest in acquiring more of these assets).* Number of self-recovers demonstrated this requirement. Need vehicle power source to recharge laptop computers containing Technical manuals for the maintenance crews. The pace of the advance did not allow for time to recharge the set with field generators. Track continued to snap on left side. CWO3 Dan Wittcop speculates possible problem is the torque caused by the more powerful engine of the Hercules. Track would simply "pop". It is recommend at least exploring a sturdier center guide for the track. Winch fragility was also addressed. Some recoveries required off angle approaches outside the recommend 20-degree angle. Recommend that an update to the TM include a reference to use a floating block in recoveries. One snapped cable was repaired in the field. However, at the time of this report a recovery was not attempted with that cable. Skirts on the M88A2 design made it difficult to do rapid track maintenance. During combat operations, removing bolts proved problematic. Recommend exploring a vehicle modification to allow for better access. A Battle Damage Repair (BDR) should, if possible, be developed for fixing cables on M88A2.

Armored Vehicle Launched Bridge (AVLB) AVLB ~ Not employed to any great extent during operations. However, many in the 2D tank battalion cited the need for an improved AVLB variant. Throughout operations, the AVLB was slow, achieving speeds of only 20mph. It was recommended that HETs be used to transport AVLBs. AVLB is at the end of its life cycle. Spares were difficult to get. AVLB track was in short supply. AVLB track was repaired with SL-3 on vehicle. Once that ran out, track from non-operational AVLBs was used. Only two of the battalion's AVLBs made it to the site at Ad-Diwaniyah at the time of this interview. It is recommended that MCSC should coordinate with Requirements and the Advocate IOT POM for a variant that can keep pace with the M1A1. LAR Marines offered some unique perspectives based on their mission experiences. One Marine suggested that AVLB assets were needed forward with LAR. They proposed a lightweight "LAR" MCL Bridge variant or a faster tracked MCL 70 ton variant.

Drivers Vision Enhancer (DVE) ~ Crews stated that the DVE had an excellent picture. Some users requested a wider field of view. In addition, crewmen had zero depth perception. It was a plus to be able to see through dust and smoke.

One maintenance complaint was that the connection cable (about the first four inches) continued to break. Bravo Company had five cable breaks and had to splice and duct tape. Crewmen also complained of not having a battery back up. Crewman felt that the DVE was far superior to the older Night Optical Device (NOD) that used passive IR. After four to five hours of continuous use, some drivers experienced dizziness and blurred vision. However, in most cases this was not considered too severe. Scouts and TOWs requested HMMWV mounts for DVEs similar to U.S. Army platforms.

Tank-Infantry Phone ~ The TI phone allowed for close communication between armor and infantry units. During the Battle of City Palace in Baghdad, Company A, 2D Tank Battalion attached to 1st Bn 5th Marines. Tanks worked in direct support of infantry. Infantrymen used the TI phone to direct tank fires in the urban fight. In one instance, infantry talked a tank crew on an enemy sniper position and eliminated the threat with 120mm main gunfire. The tanks with armor protection, thermal sights, and precision weapons became valuable "armored OPs" according to Capt. Sudmyer, Alpha Company Commander. He went on to relate the TI phone was a very useful tool in the coordinating the armor and infantry. With the extended cable, there were no exposure problems for the infantry. The TI phone was considered to have a very simple and rugged design. No significant corrosion occurred in the Iraqi climate. Initial kits delivered to theater were missing some mounting bolts. Interconnectivity cable was a little short on some kits but posed no serious problems. Capt Garcia recommended a use sheet for the infantry on the inner door panel. A simple instruction sheet on the phone and Vic-3 intercom might prove helpful in the future.

QuikClot by Z-Medica ~ 2D Tank Battalion Surgeon LT Bruce Webb (USN) stated that Quik-Clot was ineffective (specifically, it was ineffective on arterial bleeding). Battalion Corpsman attempted to use Quik-Clot in three separate occasions:

- Wounded Iraqi civilian. Shot near brachial artery. Quik Clot was applied per the instructions. The substance dried but was flaking off. Standard direct pressure applied by corpsman proved more effective on the patient.
- Iraqi civilian shot in back with punctured spine. Quik-Clot applied to severe bleeding. Pressure from bleeding sprayed Quik-Clot away. According to LT Webb, "Quik-Clot was everywhere but the wound".
- Iraqi civilian, female, shot in femoral artery. She suffered severe arterial bleeding. Patient bled out. Quik-clot unable to be applied effectively due to pressure of blood flow from wound. Patient died.
- An LAR Marine was shot in the femoral artery. Quick Clot was applied to the heavily bleeding wound. The pressure from the blood soon caused the quick clot to be pushed out of the wound and rendered ineffective. A tourniquet was applied instead. The patient died.

Quik Clot may work if applied in a "buddy system" manner. One individual applies the Quik Clot substance while another individual quickly applies the sterile gauze to the wound. However, applying the Quik-Clot as directed proved ineffective. Direct pressure and tourniquets were used instead. *(note: different opinion from the MEU MO I interviewed. Recommend further study on this item).*

Tourniquet ~ Non-pneumatic tourniquet (NSN 6515-00-383-0565) ½ by 42 inches in the corpsman medical kits proved ineffective. The tourniquet tended to slip around thigh or arm while attempting to tighten buckle. In the end medical personnel resorted to green sling and stick to tighten around pressure points to stem the flow of arterial bleeding in the extremities.
Need to keep effective battle dressings in Individual First Aid Kits.

Bustle Rack Extension (M1A1 MBT) ~ Bustle Rack Extension was rated as an excellent piece of equipment and demonstrated definite utility. However, the added weight with flexcell was estimated to be a cause of motor brakes burning out, though not conclusively proven.

Gypsy Racks ~ Gypsy Racks were rated as excellent, durable, and rugged. "Gypsy Racks were a great piece of equipment". Distribution was a problem. Not enough got to the units prior to LD. 1st LAR modified some to fit their Light Armored vehicles. Suggest manufacturers modification in future for LAVs. Similar requirement fulfilled by Bustle Rack Extension on M1A1 Main Battle Tank. Weight of gear in gypsy rack occasionally pulled down the HMMWVs tailgate. The field expedient work around used was a bolt where the tailgate mates with the vehicle in the up position.

MPAT 120mm round ~ The MPAT 120mm tank round was used extensively during campaign. However, 2D Tank Battalion had problems with rounds sticking in gun tube after 1 hour of battle carry. Rounds had to be fired off or manually extracted. In on instance, a gun tube was inoperable due to a stuck round. The warhead of that round is still

in the gun tube as the report this written. The lot number is being investigated. One theory is that the plastic wrapping around the fins to convert the round from 105mm to 120mm may be the culprit. The heat of gun tube may cause expansion of this material resulting in the rounds becoming stuck. It is important to note that in all but one case, the rounds were fired out or manually extracted by the crews. No significant degrading was reported during engagements.

Snap Road Block Kit ~ LAR Marines identified a requirement for a Snap Road Block Kit. Items included public address system, cones, placards, beacons, etc. Kit is in use by United States Army and is in their supply system.

ROC-V Vehicle ID proved useful to the battalions. Need for better thermal identification training at extreme ranges. Thermal sights at range in excess of 3000 meters appeared as "blobbed" and distorted. Presented problems in shoot-no-shoot situations.

External Auxiliary Power Unit (EAPU) ~ A quieter system was recommended. Solar Trickle Panels were also recommended for recharging batteries. Units need them to reduce wear and tear on vehicle power and generators. Army has embedded solar panels in electronic heavy vehicles to power systems. Some solar panels are capable of generating 90 watts of power. With more systems being added to vehicles. Power training on batteries is an issue that should be address. Tactical situations do not always allow for operating under vehicle or External power (EAPU).

M1A1 MBT Loader's Weapons Station ~ Need for butt stock kit for the loader's 240 7.62mm machine gun. Useful in MOUT. Also need an articulating mount and gunners shield similar to ACAV variants on U.S. Army M113 armored personnel carries only. Additional Armor Protection would prove useful in close fight. Even a kit that could be applied for urban mission and removed for other contingencies could be useful.

M1A1 MBT Tank Commander's Weapons Station ~ More ammunition is needed for the caliber .50 M48 machine at the commander's weapons station. It is hazardous for the tank commander to reload the weapon during combat conditions. The battalion received heavy amounts of small arms fire during operations in Iraq. When the 100 rounds of .50 cal were exhausted, tank commanders would have to wait for the conclusion of engagements to reload. Recommendation: the need for a greater ammunition capability. Perhaps a larger ammunition compartment on the mount

Kevlar lined HMMWV ~ Helped absorb the blast of an RPG and prevented catastrophic damage to the vehicle and crew.

Kevlar " kidney pads" ~ Were suggested for some soft skinned vehicle crewmen.

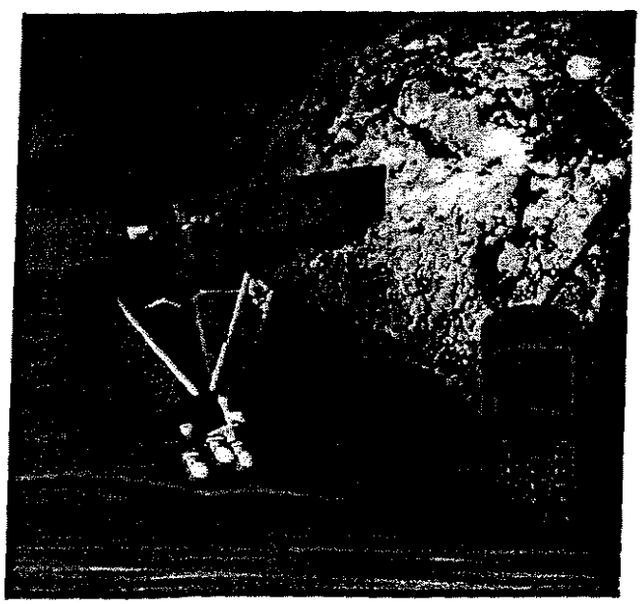
Battle Damage Repair (BDR) for bore evacuators ~ Bore evacuators on the 120mm that we damaged by small arms were patch welded by battalion maintenance.

Logistics Comments ~Need HEMMET refuelers. Need more reliable fuel pumps. Water pumps had to be cannibalized to keep re-fuelers operational. Faster pumps also needed. The tank battalions have legitimate requirement for extended bed MTVRs. Two pods and a pump to fit on one bed of extended MTVR. LVS has exceeded its life cycle and proved mechanically unreliable. Recommend Four Heavy Equipment Transports (HETs) per battalion.

EXHIBIT E

Military Information Technology Magazine
5/21/03

Users Flock to Satellite Phone System



Enhanced Mobile Satellite Services provide voice and data communications from mobile, lightweight terminals

By Sylvie Ellen

A medevac touches down in an isolated valley and rescues an injured warfighter.

After an explosion possibly caused by terrorists, commercial communications are down or overrun with users. But personnel on the scene are able to contact those with the ability to lend assistance in a time of crisis.

A soldier on deployment in Afghanistan has a spare moment and is able to speak to his wife and children with all the clarity and ease of a local telephone call.

These three separate scenarios are representative of how the Enhanced Mobile Satellite Services (EMSS) communication system operated by the Defense Information Systems Agency (DISA), is helping U.S. forces with improved satellite communications.

The EMSS Iridium handset is a satellite-based personal communications system that utilizes the Iridium satellite infrastructure. It provides voice and low-rate data services from mobile, lightweight terminals through a Department of Defense (DoD) dedicated gateway. It accesses the Defense Information Services Network (DISN) and is capable of

services.

"When DoD got involved with this system, they never said that this was a tactical only system," said Lieutenant Commander Augustine J. Ponturiero, chief of operations for EMSS at DISA. "We leave the usage of this system up to the unit commander. What we are seeing in usage right now out in the field is that it is being used for tactical operations—for logistics, medevac support, morale, welfare and recreation calls. We're seeing this one system being used across the entire spectrum of need for the deployed user."

The EMSS gateway was activated in 1998 as part of the global Iridium network. The satellite constellation owner and operator, however, filed for bankruptcy protection the following year. The resources were then purchased by Iridium Satellite in November 2000 and returned to commercial service in April 2001.

The Iridium satellite constellation consists of six polar orbital planes, with 11 satellites in each plane, plus one in-orbit spare. This 66-satellite low-earth orbit constellation provides global coverage pole-to-pole, with direct satellite-to-satellite cross-links to minimize voice transmission delay and provide alternate routing. Although the system is designed and optimized for voice transmission, it also offers data service up to 10 kilobits per second.

"We wanted a system that was global, that was hand-held and that could support encryption, voice and data transmission over the globe," Ponturiero said.

Department officials determined that Iridium would meet these and other goals. "DoD figured that we could get more of our goals met by having our own gateway. We built our own purpose gateway on the Iridium system," he said.

Secure service is made possible through DoD's own gateway, because a call made on the system never touches ground until it gets to the DoD-owned and operated gateway in Hawaii. Calls are routed to the FTS2001 system, the Defense Switch Network (DSN), the standard commercial long-distance network, the international long-distance network, local 1-800 access networks and NIPRNet, the sensitive but unclassified defense-wide network, Ponturiero explained.

"That's where we are today," Ponturiero said. "We're hoping to expand that into allowing connectivity to the SIPRNet, which is our classified network. It's actually been quite good at meeting all of those requirements."

System Constraints

and Solutions

Although EMSS is very advanced, it does have some constraints. The units must have a line of sight to a satellite to fully operate, for example, so the product is geared more

situation, however, and Ponturiero said that new ways to improve reception capabilities are in the works.

"There's about three or four different ways, at least, that we can hook up a solution to a building," he said.

The phone's low data rate—from 2.4 kilobits to 9.6 kilobits per second—is another limitation. But Ponturiero points out that the Iridium handset does e-mail very well, and Web sites can be connected to very quickly if an image option is disabled on the handset.

Not only can the system connect to a terrestrial network through the NIPRNet, but it can also connect handset to handset. "If I've got a laptop, you and I can share data real time," Ponturiero said. "I can type almost like we're in chat format, or I can send courses and speeds. I can send positions, I can send data that I'm collecting so you can see it directly for analysis."

To increase the data throughput, a few companies are working on a way to operate the phones in tandem with a front-end processor.

"General Dynamics Decision Systems is working on a multiplexed phone unit that would offer higher-speed data capability through Iridium," said Ponturiero. "They have a prototype, and it's impressive. The four-phone multiplexed unit, called an IMUX, would be about the size of a briefcase."

One of the primary advantages of DoD owning and operating its own gateway is that it allows EMSS to provide secure voice communications and also protect user information. This is critical because of the nature of military communications, as well as the importance of maintaining the safety of the individuals communicating.

"All of our user information—where they are, how long their phone call is, who they are and so on—is all protected behind our walls," Ponturiero said. "And that makes perfect sense for our DoD folks."

On a standard commercial satellite or cell network, there is always some positional information that is shared with the system for billing and other reasons. DoD has a large incentive to not have that information released, even into friendly hands. "With our system, all that information comes back to a DoD facility, and we don't share it with anybody. We don't need it for billing purposes, we don't share it with Iridium. We keep it," Ponturiero explained.

EMSS is proving itself useful overseas, with DoD currently maintaining a 20,000 user license. An EMSS system can be found wherever troops are deployed in the world. "EMSS reached a milestone in January with more than one million call minutes, our highest monthly usage total since inception. The majority of traffic is in direct support to deployed warfighters." Ponturiero said.

The September 11 terrorist attacks and the increased movement of troops into areas with limited communications infrastructure have both played an important role in the increase in usage of EMSS. Emergencies have had the effect of increasing usage, according to Ponturiero, because of the system's ability to work when there are problems with terrestrial networks or cellular infrastructure.

Although EMSS's usage rate this past Thanksgiving was a high of about 39,000 minutes of usage, the system ran at only about 30 percent of its capacity for the entire month of November. Increased usage is an important goal for EMSS, Ponturiero explained.

"On any given day, we're operating at a 16 percent load," he said. "So that means we've got 84 percent capacity standing by to provide need for surge communications, and running the full range of morale to tactical operations. We've got the capabilities."

These communications capabilities can extend to every part of the military. Because the system is interoperable, members of all services can use it to communicate with each other. "We distribute across the entire spectrum of DoD: Navy, Marine Corps, Army, Air Force, most DoD agencies, the Coast Guard and the combatant commands like CENTCOM, SOUTHCOM and SOCOM," Ponturiero said. "We have a good mix."

While the handsets are predominately being used by DoD personnel, a number of other federal agencies are also using the Iridium handsets, such as law enforcement, veterans' hospitals and members of the banking community, including the Departments of Treasury and Commerce. "They've actually had theirs since Y2K, because they were concerned there was going to be a [communication] problem with Y2K issues. We've maintained service for those organizations," said Ponturiero.

EXHIBIT F

Technical Appendix

Prepared by Mark Adams
Chief Technology Officer

July 11, 2003

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1.0 Iridium Spectrum Efficiency

From its inception, the fundamental design driver for the Iridium system was maximization of spectral efficiency, at both L-band and Ka-band. As a consequence of the limited bandwidth assigned to the Iridium in its final space station license two additional (major) design modifications were implemented prior to initial commercial activation in 1998.

The Iridium system has incorporated advanced technologies intended to maximize spectral efficiency (in both the L-band and Ka-band) and (therefore) system capacity. Among Iridium's distinguishing design features are:

1. Onboard processing: By demodulating all L-band channel data (both uplink and downlink) the satellite is able to compact the baseband user data more efficiently. This advanced technology, seldom used on commercial spacecraft, reduces the required crosslink and feederlink spectrum, while simultaneously optimizing end-to-end link performance.

2. Inter-satellite crosslinks: This advanced technology, used mainly in state-of-the-art DoD or NASA satellites, enables the Iridium system to provide true global coverage while minimizing the number of gateways required worldwide. This, is turn, reduces the system-wide requirement for scarce feederlink spectral resources.

3. On-board real-time modulator/demodulator-to-beam switching: The unique design feature enables each satellite to assign significant percentages of the satellite modulator/ demodulator hardware to a concentrated number of beams autonomously – thereby enabling the satellite to service highly concentrated traffic regions inside its footprint. It is this feature that allowed the Iridium system to respond, instantaneously, to the STA grant of temporary spectrum.

4. Intra and Inter Satellite Frequency Reuse: Like its terrestrial GSM counterpart, the Iridium system relies heavily on frequency reuse to maximize its system capacity and therefore spectral efficiency. Each distinct L-band carrier frequency employed in the Iridium system can be re-used in both the time and space dimension. Up to four way reuse in time (even inside of a single beam) is accomplished via the four TDMA timeslots. Furthermore, each carrier/timeslot combination can be reused

several times inside of a single satellite footprint (i.e., reused between geographically separated beams).

After the Iridium operational bandwidth was established at 5.15 MHz (vs. the original operational bandwidth design of 10.5 MHz) the Iridium design underwent two significant modifications in order to allow the system to go forward, albeit at a significantly reduced capacity.

1. The first design modification was the addition of Autonomous Satellite Based Real-Time Dynamic Channel Management: This unique design feature is incorporated into the Iridium satellite payload software and allows each satellite to assign satellite capacity autonomously to high traffic areas without ground planning or intervention. This feature significantly enhances the ability of each satellite to react to real-time traffic demands independent of historical traffic patterns in the affected region, and without commanding from the satellite control facility or gateways. This space vehicle real-time (SVRT) dynamic software continuously allocates, de-allocates, and reallocates user-link (L-band) spectrum (and hardware) in response to the offered traffic load, while simultaneously: a) optimizing traffic capacity, b) maximizing desired carrier-to-interference ratios between reuse beams, and c) minimizing reuse channel conflicts between satellites. This SVRT dynamic channel assignment feature is unique to current generation MSS systems, and was implemented at significant cost (and risk) to the program, but resulted in a greatly enhanced system spectral efficiency. Appendix A provides additional details on this very unique feature

2. The second major modification made in response to the 5.15 MHz allocation was the disabling of both full rate voice and full rate data services. As originally designed, the Iridium system provided both half-rate (2.4 kbps) and full-rate (4.8 kbps) voice and data services. The selection of voice/data mode was designed to be selectable during call setup (via handset-to-gateway signaling). In areas where traffic demand was high the gateway could limit calls to half-rate, while allowing the vast majority of calls to operate at full-rate. As a consequence of the limited spectrum made available to the Iridium system, operation has been limited to half-rate mode since the original commercial activation in 1998. The system hardware remains fully capable of implementing this full rate feature – and only satellite software modifications would be required to implement this service.

2.0 Iridium System Channel Management Capabilities

2.1 System Design Overview

During the early design phase of the Iridium program numerous air-interface alternatives were investigated for incorporation into the satellite-to-user (L-band) link. Design options considered included derivatives of both analog CMRS standards (e.g., modified versions of IS-91 AMPS systems), and digital standards (e.g., GSM derivatives and IS-95 CDMA derivatives). In evaluating each of these alternatives, the early system design requirements included the following criteria:

a) A requirement to optimize the achievable spectral efficiency (therefore system capacity) within a limited MSS bandwidth,

b) A requirement to maximize compatibility with existing CMRS air-interfaces at both the physical layer, and at the higher protocol layers at which the supportable services/features are defined,

c) A requirement to support both full-rate and half-rate vocoded voice[1], and

d) A requirement to provide seamless global coverage to all areas of the world.

Early analyses/simulations of CDMA alternatives showed that the long NGSO path delays essentially negated the ability to combat rapid multipath fading via fast Adaptive Power Control (APC) – a feature that is of critical importance in minimizing co-channel multiple access interference (MAI) in cellular CDMA systems – and therefore overall system capacity and spectral efficiency. With this fundamental limitation on APC, our system tradeoff analyses showed a dramatic reduction in the achievable spectral efficiency as compared to the spectral efficiencies associated with terrestrial CDMA cellular implementations.

After a comprehensive tradeoff analysis, the final Iridium system air interface was modeled after the Global System for Mobile Communications (GSM), as specified by the European Telecommunications Standards Institute (ETSI). While the Iridium air interface was modified from the GSM standard to enable operation consistent with an

[1] As currently implemented, the Iridium system supports only half-rate voice. This reduction in functionality was a direct result of the bandwidth allocation ultimately assigned to the Iridium system as a result of the Big LEO band plan and the FCC Big LEO MSS Report and Order.

NGSO MSS transport mechanism, various aspects of the underlying L-band air interface closely resemble GSM air interface.

For example, the Iridium system channelization plan utilizes combined frequency division multiple-access (FDMA) and time-division-multiple-access (TDMA) channel structure. Additionally, the Iridium system TDMA/FDMA air-interface plan includes overhead/control channels to support functionality identical to that specified within the GSM standard (e.g., system broadcast channels (BCCH), and system random access channels (RACH)). It should be noted that the original Iridium air interface also includes all the signaling necessary to support both full-rate vocoder and half-rate vocoder traffic channels (TCH). Analogous to GSM CMRS systems, the Iridium system was also designed to reuse frequency channels many times, both within an individual satellite footprint and across the system's global coverage area.

Among the Iridium air interface changes that were required to enable operation over an NGSO MSS transport medium were: a) modification of the underlying TDMA frame structure and duration, and b) modification of the full duplex TDMA implementation to a time division duplex (TDD/TDMA) implementation.

The later change was instituted to more closely conform to the spectrum limitations associated with the original Big LEO MSS band. At the time of original system design/development the decision to change to a TDD air-interface format was deemed to present a lower risk, while simultaneously allowing for a higher overall spectral efficiency. As a result, the Iridium system incorporates a TDD/TDMA/FDMA air-interface that is designed for single-band (as opposed to split band) operation in the Big LEO MSS L-band spectrum between 1616.0 – 1626.5 MHz[1].

It should be noted that all Iridium satellite hardware, and end-user equipment(s), are capable of utilizing the full 10.5 MHz design bandwidth. However, to date, operation of the Iridium system has been more spectrum constrained in accordance with the Big LEO R&O[1] and Big LEO Band Sharing Plan.[2] Given the amount of overhead resources required to support the GSM-like control channels, the impact of this reduced bandwidth on system capacity has been substantial.

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[1] In the Matter of Amendment of the Commission's Rules to Establish Rules and Policies Pertaining to a Mobile Satellite Service in the 1610-1626.5/2483.5-2500 MHz Frequency Band, 9 F.C.C. Rcd. 5936 (1994)("Big LEO Order").

[2] Report of the MSS Above 1 GHz Negotiated Rulemaking Committee, April 6, 1993.

Implications of Truly Global Coverage: Given Iridium's unique ability to provide truly global coverage, the geographical distribution of the traffic load that is offered to the satellites will vary from relatively uniformly distributed across a satellite's footprint, to highly concentrated within a few beams on the satellite. While the system, by design, is uniquely capable of providing a high level of flexibility in response to these diverse traffic patterns, the above operating band limitation (5.15 MHz vs. 10.5 MHz design bandwidth) has had a significant impact on the system's resulting user-link capacity and, therefore, ability to generate revenue.

2.2 System Design Features

In order to maximize satellite capacity, optimize achievable spectral efficiency, and meet the variable service/traffic requirements around the world, the Iridium satellites incorporate inter-satellite crosslinks and unique onboard processing. From its inception, the sole purpose of this elaborate design was to provide the necessary flexibility to serve dynamically widely disparate traffic loads. Among some of the key system design features are:

- ***Onboard Switching:*** Onboard switching that supports dynamic assignment of modulator/demodulator hardware (and therefore traffic channel capacity) between beams. This hardware re-mapping occurs continuously (at eight millisecond intervals) in response to mobile earth terminal (MET) requests for service and beam-to-beam handoffs, and is autonomously implemented by the satellite (requires no real time ground commanding).

- ***Intra-Satellite Frequency Reuse:*** In order to maximize the system's spectral efficiency, frequency channels can be reused multiple times across multiple satellite beams.

- ***Real Time Autonomous Intra-Satellite Resource Control:*** Continuous, real time satellite based control of L-band capacity. This is implemented by dynamic control of both the frequency channelization (FDMA) plan, and timeslot (TDMA) utilization across all satellite 48 beams.

  This real time autonomous response to the offered load allocates, reallocates and de-allocates user-link (L-band) capacity continuously between beams. This dynamic capacity algorithm: a) optimizes system traffic carrying capacity while, b) ensuring that all active user links achieve a sufficient level of intra-system

signal-to-co-channel noise ratio (necessary to meet the system's voice quality requirements), and c) ensuring sufficient capacity is available to provide beam-to-beam (and satellite-to-satellite) handoffs.

This dynamic channel assignment feature is unique to current generation MSS system design and greatly enhances the system's achievable spectral efficiency. This feature allows the satellite to significantly increase instantaneous beam capacity *(by approximately 5000%)* above the initial channel assignment plan.

- ***Real Time Autonomous Inter-Satellite Resource Control:*** All nearby satellites continuously (and autonomously) coordinate frequency utilization to optimize adjacent satellite frequency use and reuse, while simultaneously minimizing co-channel interference between neighboring satellites.
- ***Onboard demodulation/re-modulation:*** By incorporating onboard demodulation/re-modulation the satellites are able to optimize link margin and provide user-to-gateway and, via cut-through mode, direct user-to-user communications as dictated by the call origination and destination (PSTN or MET).

Taken as a whole, the Iridium satellite design provides a capability unique to current generation MSS systems. It is the above unique capabilities that allow the system to optimize traffic handling flexibility and capacity, while simultaneously optimizing the system's spectral efficiency.

2.3 Channel Management Process and Associated Capacity Constraints

The objective of the Iridium channel management process is to maximize the traffic handling capacity available in the system while maintaining acceptable levels of: internal system interference, blocked calls, and dropped calls. Available system level capacity is directly dependent upon the density with which frequencies and time slots (a combination of which defines a channel "reuse unit") are spatially reused. As this reuse density is increased however, the system self-interference levels also increase.

2.3.1 Channel Management/Resource Allocation

The channel assignment function runs autonomously on all operational satellites and assigns channels in response providing the required overhead control channels (e.g., system broadcast channels (BCCH), and system random access channels (RACH)) and to real time demand from the Iridium mobile earth terminals (METs). In addition to

assigning/managing its own channel resources, the channel assignment function must simultaneously identify and track changes in channel resources on all nearby satellites, in order to minimize intra-system, inter-satellite C/I effects.

The key functions performed by the channel management/resource allocation algorithms are the identification of the most efficient set of L-band resources (spectral and hardware) to be allocated to each beam. Global coverage means that each point on the earth must be covered by at least one beam (from a possible 3168 available beams). Each active beam must provide the required overhead/control channels needed to support functionality identical to that specified within the GSM standard. In addition, the channel management/resource allocation must also provide the additional capacity needed to meet the instantaneous traffic demand. Resources must be allocated so as to optimize reuse of the radio frequencies within the constraints imposed by the available spectrum, self interference, currently available satellite hardware, dynamic satellite constellation topology, and the amount of peaking in the communication load which is presented to the constellation.

One of the key quality-of-service (QOS) metrics that is actively managed/tracked on the system is the rate at which calls are dropped due to lack of available channel resources. Much like base station to base station handoffs in GSM CMRS systems, traffic channel assignments are not maintained within the Iridium system during beam-to-beam (or satellite-to-satellite) handoffs. Rather, the MET is always assigned a new channel from the pool of resources available on the new beam (or satellite). In order to minimize the number of dropped calls due to insufficient channel resources., the Iridium system must always maintain an adequate reserve of unused channels for assignment to users that require a beam-to-beam handoff (due to satellite motion).

2.3.2 System Capacity Optimization Design Features

In order to provide a graceful response to high instantaneous traffic demands the satellites include additional design features intended to simultaneously: a) maintain all transmit chains/amplifiers in their linear operating region, b) limit new entries onto the system when the satellite is operating at or beyond rated capacity, and d) avoid onboard computer processing backlogs/overload.

- ***Amplifier Dynamic Range Management:*** All transmit amplifiers in the L-band payload are continuously monitored for indications that they are approaching peak rated drive levels. When these conditions are detected the system will

incrementally reduce RF drive level (user downlink signals) in order to maintain linear operation and eliminate any potential for both in-band and out-of-band spurious emissions. This "drive level control" functionality is an integral element in the optimization of Iridium's traffic carrying capability.

- ***New Call Flow Control:*** When predefined load limits are reached on either individual beams or on the satellite new call attempts are denied entry into the affected satellite (and only the affected satellite) in order to maintain a high quality of service to those calls already in progress. This ensures that adequate resources are available to perform beam-to-beam handoff s, inter-satellite handoffs, and to continue to provide new service to high priority users.

- ***Processor Rate Flow Control:*** Various processor queues are continuously monitored in the L-band payload in order to detect processor issues associated with high traffic volume. For example, when a pre-specified number of calls are queued up waiting for a beam-to-beam or inter-satellite handoff, the satellite will deny new call attempts in order to devote more processor time to ongoing calls.

2.3.3 Capacity Limitations - Payload Channel Assignment Process

The L-band onboard processing payload (depicted in Fig 1) is a complex combination of a two-layer switch, 32 frequency-agile tuners (with fixed connections to the input side of switch) along with associated modem hardware, and 48 beam up-converters (hardwired between the switch output and the phased array antenna beams).

The payload was designed to operate over a 10.5 MHz. bandwidth. Lack of sufficient spectrum compounds specific payload operational constraints which in turn limits the flexibility in providing reuse channels to heavily loaded beams, among these are: a) the limited tuning range of the tuners, b) fixed tuning of the tuners for the duration of the user transmit and receive portions of the 90 millisecond L-Band frame, and c) interconnectivity limitations of the two layer switch (switching occurs continuously at eight millisecond intervals).

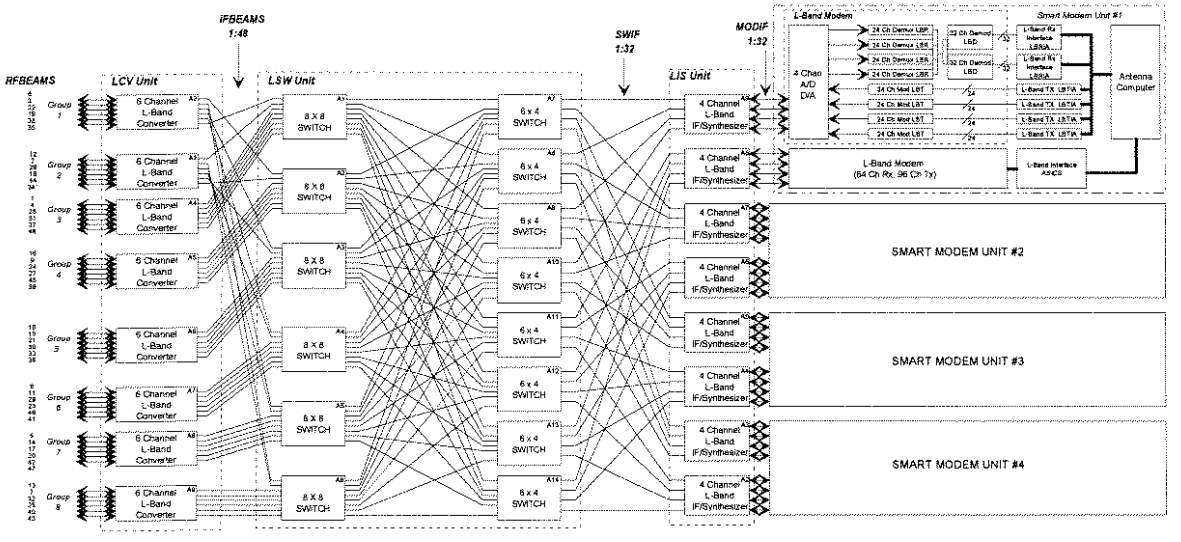

Fig 1: Iridium L-Band Payload Block Diagram

Generally, the satellite will try many alternate hardware configurations (a combination of time slot, switch settings and tuner/tuner frequency settings) to satisfy requests for new channels or handoff channels. However, as the satellite load increases, the specific set of reuse units (frequency/time slot allocation) in use and the sequence in which they were configured will present a hardware constraint that will not permit the assignment of more channels. If all remaining/unallocated reuse units are tried without success, the calls that need these resources are likely to be denied/dropped. The addition of more spectrum greatly reduces the impact of the Hardware constraints.

2.3.4 Channel Management Interference Considerations

The Iridium subscriber link performance depends on avoiding significant levels of interference at the subscriber link receivers. The system link budget has been designed to tolerate a carrier-to-interference ratio (C/I) of up to 15 dB -- which results in a sensitivity loss of approximately 1.0 dB in the overall link. When the C/I decreases below this level, the loss in sensitivity increases very rapidly and the link must either increase the transmitter power (which squanders resources), or, if additional power is not available, the link becomes more susceptible to channel fading and may drop. In addition to the loss in link performance, excess downlink C/I adversely affects the accuracy of the MET power measurement process. This in turn can result in dropped calls due to inappropriate handoff behavior. To avoid these effects, the channel management process must allocate

and assign channels so that the resulting C/I remains above a minimum threshold for essentially all active channels.

Interference control in Iridium takes into account the unique aspects of operating with low earth orbit satellites. For example, unlike the case for a terrestrial cellular system, the frequency plan that is able to handle heavy loads must be constantly revised to compensate for the continuously changing locations of the satellites relative to each other and to the ground MET equipment. Further, the channel management function must compensate for the asymmetric nature of the uplink and downlink interference -- the interference environment seen on the uplink is very different from the interference environment seen on the downlink.

This asymmetry arises from the fact that the downlink interference is generated by the satellite(s) that are in the line of sight of a particular point on the earth (i.e., the MET) at any particular time. This represents a very limited number of point sources, i.e., satellites (the count of visible satellites seldom exceeds ten – and typically is much less). However, the interference on the uplink is generated by all METs within the line of sight of a particular satellite. This is generally a very large number, and can exceed several hundred, or more.

The channel management process also considers the fact that when one channel interferes with a second channel, the reverse is seldom true, but the second channel may well interfere with yet a third channel. The differences in propagation delays and Doppler frequencies on the uplink and downlink channels also make it very unlikely that two channels that interfere on the uplink will also interfere on the downlink, or vice versa. With all of this asymmetry, it is imperative that the channel management process assign channels so that the interference levels are simultaneously tolerable in both the uplink and the downlink of a call connection.

The actual interference environment seen by a particular Iridium connection is extremely dynamic. Interference sources come and go as the satellites move, as other calls originate, handoff or hang up, and as the individual speakers talk or listen. Nevertheless, the channel management process recognizes and compensates for the fact that any particular interference source may disrupt a connection. Interference maintenance runs on a periodic basis to ensure that the best channel allocation available is provided, and moves users accordingly. Once a user is assigned a channel, that user will generally remain on the channel for roughly 30 seconds to a minute before the next beam-to-beam handoff.

3.0 Additional Spectrum and Efficiency

Similar to terrestrial-based cellular systems, Iridium utilizes frequency channel reuse both within a satellite footprint and between satellites. Since these satellites are traveling extremely quickly relative to the subscriber units, these reuse algorithms are quite complex to adapt to a highly dynamic satellite spot beam geometry relative to the active subscriber base. In addition, each user is transitioned from one spot beam to the next within sixty seconds and between satellites every 8 minutes. Effective reuse becomes increasingly difficult to achieve when available spectrum becomes more constrained. This added complexity results from both the constancy of the overhead channel requirement and the constrained flexibility afforded by the scarcity of the remaining available spectrum to accommodate inter/intra satellite hand-off and new acquisitions. Since the Iridium system reuses channels from beam-to-beam when sufficient spatial isolation exists to avoid interference, as fewer channels are available, finding an available channel with acceptable characteristics becomes increasingly difficult.

Additional spectrum very significantly improves the spectral efficiency of the Iridium system since the reuse process become far more effective when the degree of reuse freedom is expanded. Intra-satellite beam handoffs, inter-satellite handoffs, new channel allocation and the on-board satellite payload computing process are all directly and significantly enhanced by additional spectrum.